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ABSTRACT

Reconstructing media research so that generalizable knowledge can be produced requires an increased emphasis on attributes of media which interact with individual differences to effect learning. In order to accomplish this, media researchers must make a distinction between research "with" media and research "on" media. Privious efforts to systematize the selection of media for instruction by developing taxonomies generally have not been derived from previous research; they also do not draw on previous efforts to organize or conceptualize individual differences in learners. An alternative approach to the structuring and testing of media attribute taxonomies might list attributes to be validated by forming a three-dimensional matrix of subjects, behaviors, and attributes. The matrix is then collapsed across each of the three factors in turn and intercorrelations factored. By collapsing across subjects, for example, it is possible to compute the correlations between all the pairs of media attributes on specific behaviors and factor analyze the intercorrelation matrix. Factors would represent functionally similar media attributes; i.e., clusters of attributes which tend to elicit the same behavior. The result would form the basis of a media taxonomy for research purposes. (Author/WCM)

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TAXONOMIZING MEDIA ATTRIBUTES FOR RESEARCH PURPOSES

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In this article, I will examine some of the problems with previous research on the use of various types of media in instruction, with an emphasis on research which has hypothesized interactions between various attributes of media and individual differences of subjects. I will also review efforts to systematize media research by constructing media taxonomies. I will then suggest an alternative approach to the structuring and testing of media attribute taxonomies for research purposes which may eventually prove useful in the design of interaction studies.

Recent critical reviews of media research (e.g. Saettler, 1968; Snow & Salomon, 1968; Gordon, 1970; Allen, 1971; Campeau, 1971; and Olson, 1974) generally conclude that we have produced very little in the way of useful research questions or a body of generalizable knowledge. An observer unfamiliar with the intricacy of media research might decide, on the basis of these reviews, that we have enjoyed a brief but inglorious history.

Most of the hypotheses that have been advanced to explain the failure of previous studies have dealt with methodological problems. Mielke (1968, 1970), for example, examined the validity of media research questions. Snow and Salomon (1968) and Schwen (1973) pointed out an absence of concern with possible interactions between various types of instructional media and student traits or aptitudes. Clark (1972) and DiVesta (1974) have recommended the aptitude-treatment interaction (Cronbach and Snow, 1973) or trait-treatment interaction (Berliner and Cahen, 1973) research methodology as a fruitful approach for research on instructional media and technology. However, the

evolution of aptitude-treatment interaction (ATI) methodology comes at a time when educational psychologists are deeply committed to the development of new measures of ability, aptitude, personality, trait, and attitude (Glaser, 1972). This expansion, however, is offset by the lack of a parallel increase in efforts to augment our knowledge about treatments.

Knowledge About Media and Aptitudes

In ATI research, a certain media treatment, say, presenting visual information in a two-dimensional versus a three-dimensional mode, is hypothesized to interact with certain learner aptitudes such as the ability to "lay out objects in space" and differentially effect attention, comprehension, learning, and so on. Working with interaction hypotheses requires that our knowledge about media and aptitudes be roughly equivalent. Mitchell (1969) suggests that our methods of characterizing treatments are "primitive", and Shulman (1970) has warned that aptitude treatment interaction research "will likely remain an empty phrase as long as aptitudes are measured by micrometer and environments are measured by divining rod." (p.374). We continue to use such terms as film strips, television, movies, audiotape, slide-tape presentations, and so on, to characterize media in research settings, even though reviews of this approach (e.g., Salomon, 1972) have indicated that the large number of "no significant differences" resulting from comparisons of treatments thus specified are not productive.

Research With Media vs. Research On Media

Salomon and Clark (1974) discuss the problem of conceptualizing types of media research and suggest that a solution may lie in a distinction between research with media and research on media. The two approaches differ not only in focus but in approach. Research with media is usually a simple

comparison of mechanical devices such as television or films or is concerned with the management of instruction, for example by presenting programmed instruction via television. Research with media provides very little knowledge about the specific medium used as treatment, nor does it provide insights about the way students learn from media presentations (Mielke, 1968).

Media Attributes

Research on media, is concerned with those relevant attributes of media which interact with individual differences to effect learning. Salomon (1970) suggested that media be defined in terms of unique presentation attributes which fulfill unique psychological functions. Levie and Dickie (1972) state that:

> A more productive conceptualization of research related to media selection is one that specifies the relevant variables in terms of the attributes of media rather than in terms of the media themselves. Media attributes are properties of stimulus materials which are manifest in the physical parameters of media. The attributes of a medium, then, are the capabilities of that medium to show objects in motion, objects in color, objects in three dimension; to provide printed words, spoken words, simultaneous visual and auditory stimuli ... Some attributes, such as the capacity to provide pictorial stimuli, are shared by many media. Other attributes, such as the capacity to show objects in three dimension, are properties of relatively few media. (p. 860).

Research with media corresponds to Tosti and Ball's (1969) "Research in Media Effects" (which they describe as theoretically insignificant) and research on media as it is used above is equivalent to their "dimensions of presentation forms" (or media attributes).

The results of a survey of research literature which focused on interactions between media attributes and individual differences is presented in Table 1. Very few studies which tested such interactions were found.

Insert Table 1 about here

When one looks at these studies a number of impressions begin to evolve: first, the studies are primarily atheoretical and the results are thus difficult to explain; second, it appears that before 1970 gross media attributes such as picture vs. text vs. verbal presentations were overwhelmingly popular. Since 1970, however, both individual difference measures and media attributes have been specified more exactly; and finally, it is revealing that a majority of these studies have used gross trait measures such as age or grade level and/or general abilities, in some cases even when very specific mental skills and operations are required from subjects.

Berliner and Cahen (1973 p. 70) in a similar classification of trait treatment interaction studies make fine distinctions between trait and aptitude measures but do not list treatments. It appears that educational psychologists have placed less emphasis on the treatment dimension and instructional media researchers have generally ignored the subtleties of

individual differences. Deemphasizing either element in this hypothesized interaction makes research results extremely difficult to interpret and theoretical work impossible.

Taxonomy Development

In order to study media attributes some systematic way must be found to describe and organize them. Meridith (1965) suggests that researchers use taxonomic schemes which he defines as "laws of arrangement". The need for research based taxonomies for instruction has been most obvious in nontraditional media oriented endeavors such as the Open University in England. Hawkridge (1973), in a paper on media taxonomies, stated:

> "The (Open) University's selection of media is controlled by logistical, financial and internal political factors rather than by soundly based clearly specified psychological and pedagogical considerations ...over 2,000 media studies have not yielded the answers we need." (p. 1)

Reviews of research which focus on media selection and instructional design (e.g. Campeau, 1971; Allen, 1971) have reached similar conclusions regarding both the instructional applicability of research results and the need for a multivariate taxonomic approach to the problem.

Taxonomies are usually developed by selecting and labeling instances of a class of objects under study and arranging them in terms of various similarities and differences between their individual properties or attributes. The most useful taxonomies have come primarily from the fields of biology, botany, and chemistry. The periodic table of elements is usually offered as an example of an outstanding taxonomic

success. The most crucial problem in taxonomy development, of course, is the actual choice of the attributes which will form the basis of the classification scheme. We may well wonder how Linnaeus chose stamens and pistils or how Mendeleev and Meyer decided on the property of atomic weights as criterial attributes for their taxonomies. When we attempt to develop a taxonomy of media attributes for use in ATI research, what selection criteria will we employ to assist us in choosing among the great number of possible classification systems?

Unlike the physical sciences, research which ultimately hopes to gain insight into human behavior must constantly consider the aptitudes and traits of human learners in any classification scheme. The fact that ATI methodology applied to media research hypothesizes an interaction between some media attributes and some student characteristics implies that a taxonomy of media attributes must be related to schemes for classifying individual differences. And, since the ultimate usefulness of any taxonomy is to increase our prediction and explanation of human behaviors, a classification scheme would have to be based on both overt and covert learning-related behaviors.

Taxonomies in Psychology and Sociology

A good deal of effort has been expended recently in the fields of psychology and social psychology to develop representative taxonomies of situations which are related to certain types of human behavior. Sells (1963a) reviewed studies which employed systematically developed treatments and concluded that

> "The most obvious need ... is (for) a more satisfactory and systematic conceptualization of the environment. This implies a

> taxonomic ... analysis of stimulus variables comparable to the trait systems that have been developed for individual difference variables." (p. 700)

Sells (1963b), for example, has made an effort to develop a preliminary taxonomy of situations for social psychologists. Essentially he has produced a hierarchically-ordered list of social situations which is admittedly incomplete, but which makes allowance for changes and additions. A few of the situational factors included are: natural aspects of the environment (temperature, atmospheric pressure, etc.), man-made aspects of the environment (social organization, institutions, and norms), significant others in the situation, background characteristics (age, sex, etc.), socioeconomic status factors and personality characteristics. Sells and his colleagues have evolved a very large list of environmental characteristics which allow for the addition of media characteristics and attributes.

Barker (1968) and Craik (1973) have provided a comprehensive review of recent developments in what has been called "ecological" or "environmental" psychology. This area has received a good deal of attention lately in psychologists' attempts to specify situations such as the physical design of buildings and rooms, structure of psychiatric treatment programs, noise levels, smells, classroom arrangements and organization types with various types of behavioral outcomes. Efforts to construct situational taxonomies have been described by Shulman (1970) and Snow (1973) for educational research, Buss (1974) for developmental psychology, and Pace and Stern (1958) for relationships between various types of college environments and student behaviors. In most of these taxonomies, factors which are included in lists

of situations, settings, environments, and so on are natural givens rather than attributes. They pose the same problem for research methodologies as the one characterized earlier in the distinction between research with media and research on media. Research with situations deals with experimental aspects that exist and their relationships to certain behaviors. Each of those "natural" situations may contain a great variety of situational attributes which are criterial for the eliciting of certain types of behavior and also many attributes which contribute very little or no variance to outcomes.

One of the major goals of these taxonomies is to insure that the experimental situation is representative of the population of situations to which the educational researcher hopes to generalize. Bracht and Glass (1968) prefer the term "ecological validity" to describe this generalizability problem. For the researcher, situational concerns relate to the traditional dilemma between control procedures which enhance internal validity and the attempt to collect data in natural or ecologically valid situations in the hopes that external validity will be increased.

Previous Media Taxonomies

A decade ago, Meredith (1965) advised that taxonomies would add more precision to media research. He anticipated recent developments in both ecological psychology and ATI methodology by suggesting a reemphasis on Brunswikian notions of representative design, and he recommended four classes of variables for taxonomies: 1) Physical variables in the media which provide stimuli; 2) subject variables such as aptitudes, traits, history, and so on; 3) ecological or environmental variables (i.e. the situation or context in which mediated instruction takes place) and 4) physiological

variables associated with the responsive behavior of subjects. Meredith's variables could be summarized as media attributes, aptitudes and traits, situations, and behavioral outcomes.

Among past efforts to develop media taxonomies, Bretz (1971) has characterized various mechanical communication devices for engineers and practioners. Media are classified on seven dimensions, five of which deal with mechanical ability to present motion or still pictures with and without audio, and the remaining two classes deal with audio only and print only representations. Gropper and Glasgow (1971) attempted to systematize the selection of visuals for teachers and instructional designers. Their scheme relies heavily on the specification of management techniques (e.g. practice, feedback and so on), visual attribute types (e.g. realistic versus simulated actions or objects) and educational goals or objectives. Neither Bretz nor Gropper and Glasgow explain their procedure for choosing media attributes nor do they suggest that the relationships between visual media and objectives require further testing. No mention of individual differences in learning interacting with visual media attributes is made in either taxonomy.

Fleming (1967) provides yet another approach to taxonomy development. He investigated the assumptions made by textbook illustrators about interactions between physical types of illustrations (e.g. size, color, and so on), verbal modifiers (e.g. captions), subject matter types and instructional objectives. Fleming used previously developed taxonomies (e.g. Bloom's instructional objectives) or original lists of attributes (e.g. for physical properties of illustrations). He had judges rate the instructional appropriateness of the apparent hypotheses artists and writers had used to

design a sample of textbook visuals. He also counted the frequency of occurence of illustration attributes, captions, subject matter types and objectives and used chi-square analysis to determine interaction trends.

Fleming found a number of interaction trends between subject matter and objectives, between illustration attributes and captions, and between objective type and illustration attributes. Among the unanticipated findings in his study was the trend to use black and white pictures to elicit appreciation from learners. Fleming suggested that both his taxonomy and post hoc interactions be treated as hypotheses for further research.

Tosti and Ball (1969) in a discussion of media selection for instructional design offer six "dimensions of presentation forms" which are clearly intended as taxonomic variables. The six are: 1) Encoding form of the stimulus (pictorial, symbolic, verbal, and environmental structure); 2) duration of the stimulus (length of presentation); 3) response demand type (covert, constructed, vocal, and so on); 4) management purpose (enrichment, motivation, prescriptive); 5) management frequency (frequency of presentation changes).

These initial attempts at taxonomic development must be approached with considerable caution. They share a number of potential snares for the unguarded researcher and instructional developer. Taken individually, each approach offers useful insights. Collectively, however: 1) They generally are not derived from previous research nor do they clearly suggest hypotheses for future research and/or taxonomic development; 2) they tend to agree on the main classes of taxonomic variables useful for research (media attributes, aptitudes and traits, overt and covert outcome behaviors, and management characteristics); 3) they generally disagree on the instances selected to represent the main classes of variables and 4) they do not draw on

systematic efforts to organize individual differences in learning ability, aptitudes, or traits.

One caveat is in order here: All previous taxonomies may be more useful to the "administrative researcher" than the basic researcher. Mielke (1973) provides a distinction between administrative research, which yields information useful to decision makers, and basic research, which seeks new and generalizable knowledge. The administrative researcher would be more interested than the basic researcher in the management variables in previous taxonomies. The basic researcher is primarily concerned with the control of independent variables. What is being suggested here is the development of a taxonomy to aid the basic researcher rather than to provide the practitioner or administrator with a scheme for the selection of instructional media. To that end then, the rest of this article describes a method for building a media taxonomy.

Building Media Taxonomies for Research.

As was mentioned earlier, establishing selection criteria for media attributes remains a crucial issue in the development of taxonomies for research purposes. There are at least four methods for determining taxonomic categories. First, specific attributes can be evolved and described by reasoning from trait systems. This method was used very effectively by Peterson and Hancock (1974) in a study which utilized elements of Guilford's (1967) structure of intellect model. The experimenters selected Guilford's figural, semantic, and symbolic aptitudes as their individual difference measures and reasoned from the description of those aptitudes to construct instructional materials which they categorized as representing figural, semantic, and symbolic modes of presenting experimental treatments on

mathematical network tracing. In a previous study (Peterson and Hancock, 1973) the experimenters attempted to validate the orientation of the various treatments with limited success. "It was not possible to designate any of the instructional materials as being uniquely 'figural' (or 'verbal' or 'symbolic') in the sense of Guilford's model." The approach remains promising even though Peterson and Hancock have suggested, "The findings of this study provide further evidence attesting to the difficulty of ...(developing) instructional materials ...that are related in meaningful ways to ...cognitive factors." (p. 14)

A second method for arriving at media attributes involves reasoning from cognitive and/or affective process descriptions. Although this approach is very related to the one described above, it derives from the assumption that many process descriptions of cognition and affect (and perhaps motor skills) have not necessarily been derived from nor included in systematic structures such as the one developed by Guilford. Koran, Snow, and McDonald (1971) hypothesized an interaction between the cognitive style of field dependency, televised versus print representations of teaching skills and the learning of analytic questions. The choice of the two differing media treatments resulted from an analysis from the representational processes of field dependent and independent students. Presumably, field dependent students would have difficulty in simplifying and coding a complex visual sequence and, therefore, could be expected to benefit most from the relatively simple verbal representation of teaching skills. Salomon (1974) has called this representational process "supplanting". By this he implies that media attributes can be chosen or constructed on the basis of our assumption about whether they can supplant or provide subjects with mental operations which they need to perform a certain learning

task. Salomon (1972) hypothesized an interaction between students' verbal ability and their ability to remember details from paintings in two treatments; in the first treatment, a motion picture camera "zoomed" in and out on details of the paintings and in the second treatment, a still photograph of the entire painting was displayed. Low verbal ability students benefitted most from the "zooming" treatment presumably because the motion sequence was better able to imitate (or supplant) the mental operation required but not available from low verbal ability students. High verbal ability students benefitted most from the still photograph treatment because, it was reasoned, high verbal ability is associated with the availability of a great variety of perceptual processing schemes and the "zooming" treatment either bored them or was ignored in favor of some individualized scheme acquired by subjects. DiVesta (1974) has called this a trait-treatment-process-interaction approach.

There are at least two other ways of choosing media attributes. It is possible to reason from typical or atypical learning outcomes back to media characteristics. Specific items in Bloom's taxonomy of educational objectives would be particularly relevant here. In addition, it would be desirable to extract media attributes from treatments employed in previous media research.

All of the methods listed above for extracting media attributes are inter-related. It is vital that attributes be selected via a thorough consideration of individual differences and behaviors. However, after a preliminary list of media attributes, traits, aptitudes, and behaviors have been arrived at, how do we validate them?

Frederiksen (1972) describes the relative merits of factor, inverse factor, cluster, and facet analysis and concludes that none of them are ideal for validating taxonomies. He advises:

> "Instead of assigning situations to clusters on the basis of their mutual possession of various attributes, it is possible to group situations on the basis of their tendency to elicit similar behaviors." (p. 120)

Our list of media attributes would be included in a three dimensional matrix of subjects, behaviors, and media attributes. This matrix could be displayed as a media taxonomy "cube" such as the one depicted in Figure 1.

Insert Figure 1 about here

With a record of the behaviors associated with each subject for each media attribute it would be possible to collapse the matrix across media attributes to yield a subject x behaviors matrix and to factor the matrix of intercorrelations of the behaviors. This approach would yield a typology of behaviors (i.e. the subjects x behaviors surface in Figure 1).

Frederiksen also suggests an inverse factor analysis which, in our case, would require collapsing across media attributes and factoring the intercorrelations of subjects which would yield "people factors" and possibly new traits. Media attribute factors can also be extracted from this matrix. By collapsing across subjects, a media attributes x behaviors matrix is produced (the media attributes x behaviors surface in Figure 1). It is necessary here that the correlations between all of the pairs of media attributes be computed and that a factor analysis be performed on this

intercorrelation matrix. A high correlation between two media attributes would imply that they elicit similar behaviors. A factor, thus, represents a group of functionally similar media attributes that tend to evoke the same behaviors. It is the media attributes x subjects factoring which is of central interest to media researchers. The factors which are derived from this analysis would make up the categories in a research-oriented taxonomy of media attributes by using the functional similarity of behaviors elicited rather than the nominal similarity between attributes as the criterion for selection. The relationships suggested by a taxonomy thus derived would hold a greater pay-off potential for researchers than continuing to use "divining rods" to select treatments.

Summary and Conclusions

Reconstructing media research so that generalizable knowledge can be produced requires an increased emphasis on attributes of media which interact with individual differences to effect learning. In order to accomplish this, media researchers must make a distinction between research with media (a simple comparison between the mechanical devices which convey instructional messages) and research on media (which employs attributes of stimulus materials that are manifest in many mechanical devices for conveying instructional messages).

Previous efforts to systematize the selection of media for instruction by developing taxonomies must be approached with caution by the basic researcher. They generally are not derived from previous research and, although they tend to agree on the main classes of taxonomic variables (media attributes, individual differences and outcome behaviors), they disagree on the instances selected to represent the main classes of variables. Most importantly, perhaps,

they do not draw on previous efforts to organize or conceptualize individual differences in learners.

When attempting to construct media taxonomies for research one crucial question arises: What methods are available to describe and select relevant media attributes which interact with individual differences? The suggested approaches involve four interrelated schemes. First, one can reason from trait systems which have already been developed (e.g. Guilford's Structure of Intellect Model). Second, we might reason from cognitive and/or affective process descriptions. In this approach the taxonomy developer derives a process description of the overt and covert behaviors required to perform the task in question and "works backward" to a description of the media attribute(s) which would supplant those operations for the learner, Third, it is possible to reason from typical or atypical learning outcomes (à la Bloom's taxonomy). And finally, media researchers should extract media attributes from treatments employed in previous media research.

A list of attributes could be validated by forming a three-dimensional matrix of subjects, behaviors and attributes. In a large-scale study the behaviors associated with each media attribute for each subject is recorded. The matrix is then collapsed across each of the three factors in turn and intercorrelations can be factored. By collapsing across subjects, for example, it is possible to compute the correlations between all the pairs of media attributes on specific behaviors and factor analyze the intercorrelation matrix. Factors would represent functionally similar media attributes i.e. clusters of attributes which tend to elicit the same behavior. The resulting factor list of behaviors, subjects and media attributes would form the basis of a media taxonomy for research purposes.

Table 1

Selected Studies Hypothesizing Media Attribute-Trait/Aptitude Interactions*

Authors	Media Attribute	Trait(s) & Aptitude(s)	Dependent Measures
Audio vs. Visual vs. Reading			
Allen (1970)	Motion visuals vs. verbal	General mental ability tests	Identificati
Allen, Filep, & Cooney (1967)	Motion picture/verbal modes vs. concrete/ abstract content	General mental ability tests	Learning definitions
Bourisseau et. al (1967)	Pictorial vs. verbal	Racial group	Number of se sory respons
Carterette & Jones (1967)	Auditory vs. visual	Grade level	Word recogni
Cooper & Gaeth (1967)	Reading/listening	Grade level	Paired-assoc learning
Dilley & Paivio (1968)	Pictures vs. words	Age/grade level	Recognition
Gagne & Gropper (1965)	Motion picture vs. verbal instruction	Verbal ability/pre-achievement level	Learning
James (1962)	Reading vs. listening	Channel preference	Learning
Jenkins, Stack & Deno (1969)	Picture vs. word	Age	Recognition
Koran, Snow & McDonald (1971)	Video vs. written modeling	Film memory/general fluid ability	Acquisition teaching ski
Marantz & Dowaliby (1973)	Filmed vs. lecture presentation of verbal material	Hidden figures	Recall
Snow, Tiffin & Seibert (1965)	Filmed vs. live instruction	14 individual difference measures of ability, prior knowledge and attitude	Immediate an delayed reca
Thalberg (1964)	Reading/listening vs. difficulty level	General mental ability tests	Learning

*A number of the studies listed in this table were obtained from three secondary sources; Lumsdaine (1963), Levie and Dickie (1972), and Allen (1974). The author, of course, takes responsibility for any misrepresentation of the original articles or their secondary descriptions.

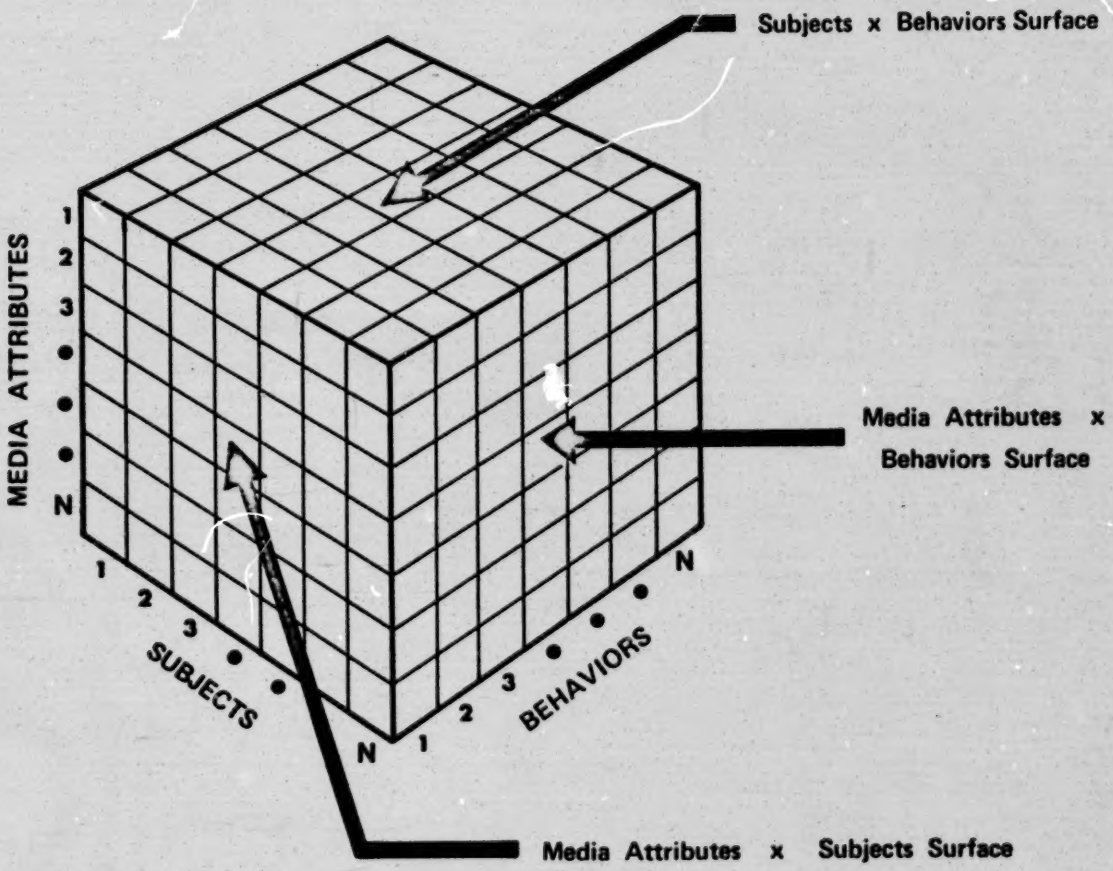
(Table 1 cont.)

Motion Variables			
Feldman (1971)	Simulations of map reading skills	Subcultural group membership	Map reading
Guba et. al (1964)	Moving vs. static visual presentation	IQ	Eye fixation
Salomon (1972)	"Zooming in on objects" "laying out objects in space" (motion vs. static presentation)	Verbal ability cue attendance & embedded figures information search	Memory for c "laying out objects" hyp thesis gener ation
Salomon (1973)	Visual modeling: 1. visually changing points of view 2. relating components to wholes visually 3. novel vs. redundant formats etc.	Social class, field dependency, picture arrangement, age	Learning
Color vs. Black/White			
Farley & Grant (1973) (post hoc discussion)	Black/white vs. color pictures	Arousal potential/ stimulation seeking	Arousal/dela effects
Kanner & Rosenstein (1960)	Color vs. B/W TV	General mental ability tests	Learning
Travers (1967) (review)	Variations in color	Age	Preference
Pictorial Design Variables			
Dwyer (1970)	Various pictorial attributes (e.g. drawing detail, color-B/W, modes vs. photographs)	Grade level	Learning
Elkind, Koegler & Go (1964)	Differing size of objects in pictures	Age	Object
Samuels (1970) (literature review)	Various types of pictorial representation	Reading ability	Reading Performance

Figural vs. Symbolic vs. Verbal Materials			
Frederick, Blount & Johnson (1968)	Figural vs. symbolic vs. verbal notation	General ability	Learning
Peterson & Hancock (1974)	Figural, symbolic or verbal modes	Pretests figural, verbal and symbolic aptitudes	Immediate ar delayed retention
Novelty & Complexity			
Clark (1970)	Variations in stimulus complexity	Locus of control & dogmatism	Information seeking
Salomon & Sieber (1970)	Randomly spliced vs. "ordered" motion pictures	Cue attendance and hypothesis generation abilities	Number of cu & hypotheses elicited
Organizers & Prompts			
Ausubel & Fitzgerald (1962)	Advanced organizers	Verbal ability	Retention
Grippin (1973)	Strong vs. weak prompt techniques	Field dependence impulsivity	Learning

Figure 1

MEDIA TAXONOMY CUBE



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